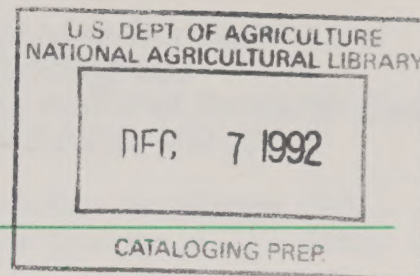


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Plant Molecular Biology Laboratory

Beltsville Agricultural Research Center
Beltsville, Maryland



Welcome to the dedication of the Plant Molecular Biology Laboratory. Today marks two beginnings. First, the completion of the renovations and remodeling of the laboratory building is a major step in an ambitious modernization of the Beltsville Agricultural Research Center. Second, the laboratory is a new focus for biotechnology. Take a tour of the facilities. We hope you will enjoy talking with our scientists about their work. Thank you for joining us.

Thursday, April 20

Auditorium, Administration Building 003

1:30 p.m.

Science Seminars, Overview of the Research
Invited Guests

Friday, April 21

Auditorium, Administration Building 003

10:00 a.m.

Welcome

*Dr. Edward B. Knipling, Beltsville Area Director,
Agricultural Research Service*

Perspective on New Laboratory

*Dr. R. Dean Plowman, Administrator,
Agricultural Research Service*

Comments

*Dr. Orville G. Bentley, Assistant Secretary for Science and Education,
U.S. Department of Agriculture*

Special Guest

*The Honorable Steny H. Hoyer
U.S. House of Representatives, Maryland, 5th District*

Keynote Speaker

*Dr. Charles J. Arntzen, Deputy Chancellor and Dean of Agriculture,
Texas A&M University*

Laboratory Mission

*Dr. Autar K. Mattoo, Research Leader,
Plant Molecular Biology Laboratory*

Plant Molecular Biology Laboratory, Building 006

11:00 a.m.

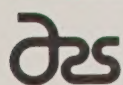
Ribbon Cutting

Congressman Hoyer, Dr. Bentley, Dr. Plowman and Dr. Arntzen

Tours and Refreshments

Media Interviews

Additional time with scientists and guests in laboratories



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RESEARCH NEWS

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Information Staff
Building 005
Agricultural Research Center
Beltsville, MD 20705

Stephen Berberich (301) 344-2720
Jim Greene (202) 447-4026

USDA TO DEDICATE NEW PLANT MOLECULAR BIOLOGY LABORATORY

WASHINGTON, Apr. 14--A new Plant Molecular Biology Laboratory, a focal point for genetic engineering in the U.S. Department of Agriculture, will be dedicated April 21 at 10 a.m. at Beltsville, Md.

"The new laboratory has a team of some of our top scientists," said R. Dean Plowman, administrator of USDA's Agricultural Research Service. "They already are providing special leadership to biotechnology programs at the Beltsville Agricultural Research Center and will be cooperating with federal, state and industry scientists nationwide.

"Future payoffs of the research may include high-protein rice and other cereal crops, highly unsaturated soybean oil, crops that steer chemical signals toward producing more food in edible plant parts and disease-resistant plants to lower pesticide needs," Plowman said.

Special guests and speakers at the dedication will include U.S. Congressman Steny H. Hoyer (5th district, Md.) and Charles J. Arntzen, deputy chancellor and dean of agriculture, Texas A&M University. Arntzen and plant physiologist Autar Mattoo, who heads the new laboratory, have made key discoveries on how certain herbicides shut down photosynthesis in plant leaves.

Dedication ceremonies will mark the beginning of a modernization program for the 80-year-old Beltsville center, the largest agricultural research facility in the country. The first fully renovated building in the program will house the new lab, which officially opened last July and will continue projects already begun.

-more-

Plowman said that despite a broad understanding of the molecular chemistry, physics and genetics of agricultural crops, scientists lack reliable and practical tools for transferring certain genes, especially those in chloroplasts--bodies within leaf cells that govern photosynthesis.

Mattoo will continue work on a special protein that acts as a spark plug to ignite photosynthesis in a cell and is a target for certain herbicides. The goals are to engineer the protein to supercharge the process--so more light energy is converted to food energy--and to transfer herbicide resistance to crops.

Another project will fine-tune a new method of injecting genes into single pollen grains, which scientists then dust onto female flower parts in hopes of obtaining seeds for transgenic plants. Other researchers have developed an experimental line of rice, the world's leading human food crop, that is more nutritious and has higher levels of protein.

"One big hurdle to genetic engineering of crops is to isolate the genes that regulate plant metabolism and development," Mattoo said. "Learning to work with such genes goes hand in hand with the more obvious need to invent and perfect methods of inserting desirable genes into a new plant."

"A related problem is isolating the minute quantities of proteins that control a plant's metabolism. Some of these proteins compose only one-millionth to one-thousandth of a cell's contents."

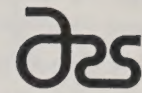
The Plant Molecular Biology Laboratory, newest of the 53 labs at the Beltsville center, is the second major USDA center of plant biotechnology to be opened recently. In November 1987, the agency dedicated the Plant Gene Expression Center, in cooperation with the University of California, at Albany. Scientists at Albany are learning how genes are expressed--turned on and off--in plants and the biochemical nature of their expression.

"The tools of molecular biology are so powerful," Mattoo said, "that unless a lab has access to those tools it is not going to remain current and first rate. I hope we can help smooth the road for cooperative research with other laboratories. Those not wholly oriented toward molecular biology will take bits and pieces from the Beltsville lab and the Albany lab to solve problems."

NOTE TO EDITOR: For details contact Autar Mattoo, research leader, Plant Molecular Biology Laboratory, ARS, USDA, Beltsville, Md. 20705. Telephone (301) 344-2103.

Plant Molecular Biology Laboratory

United States
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A Brief History of Beltsville's "West Building"

The new home of the Plant Molecular Biology Laboratory was formerly known as the West Building of the USDA Plant Industry Station at Beltsville, Maryland. The building was constructed in 1936-37 and officially opened in 1937. It was designed to be a winery--a research winery. The study of fermentation for wines and distillation of brandies was an important project, especially since prohibition had been repealed by Congress in 1933. However, one of the Senators on the Agriculture Appropriation Committee was a teetotaler. When the Senator found that there was a large still to make brandy at Beltsville he insisted that all of USDA's next year's appropriation be cut off until the still was removed. The line of research was quickly changed.

Instead, the forerunners of two pioneering research laboratories were established in the West Building--the Light and Plant Growth Laboratory and the Growth Regulator and Hormone Laboratory. Many important scientific breakthroughs in plant sciences followed, probably more than in any other building at the Research Center.

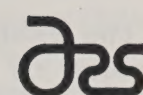
- The nature and mechanisms of photoperiod control of plants were explained and demonstrated here. The earliest work on growing plants under different colored lights (spectral light) was begun here using the largest prism yet developed. Phytochrome was discovered and isolated as a result.
- Phytochrome is a universal regulator in plants. It is a light-receptive, protein pigment universal in almost all plants in very low concentrations. Light causes a change in phytochrome from an inactive form (with absorption in the red part of the spectrum), to the active form (with absorption in the far red light). Such changes in light spectrum on phytochrome affect seed germination, flowering, stem elongation, phototropism, "sleep movements" of leaves and the orientation of chloroplasts in cells.
- Fluorescent light growth chambers were first developed in this building. The chambers were a great improvement in red light source for plant growth.
- The Viroid was discovered here. For many years scientists thought viruses were the smallest infectious self-replicating particles known. This was disproved with the discovery of the viroid. The viroid is a small bit of RNA with no protein coat that viruses typically need to readily invade cells.
- Many preliminary studies of viruses were conducted here; isolation of Tobacco Ring spot virus and the first research on Blue Green Algae Viruses (now called Cyano-Bacteria).
- Although started in California, freeze fracture of virus techniques were further developed here. This technique using electron microscopy enables researchers to obtain 3-dimensional images of viruses.
- The first brassin extraction in the U.S. was done here. Brassinins are plant steroids, growth promoters, extracted from the pollen of rape seeds. When applied to many different crops, they cause faster growth, more flowering and more fruit production.

- The powerful herbicide 2-4 D was discovered here, ushering in a new class of pesticides. Although it was a long-life chlorinated aromatic hydrocarbon, now banned in the U.S., 2-4 D was very widely used for many years.
- Naphthalen Acetic Acid, an auxin used widely in chemical thinning of apples and pears, was discovered here. It is also used as a preharvest drop spray on apples and as a growth regulator in the rooting of tissue culture plants.
- A seed testing laboratory was established in the basement in the late 1930's. Many of the optimal conditions for seed germination were established here.
- For many years a food processing plant operated on part of the first floor. Many modern food processing methods were developed there.
- A microbiology laboratory here developed tests for contamination of poultry that resulted in changes in the Federal Regulations for the inspection of poultry.
- More sensitive test methods for determining the amounts of pesticide residues in milk were developed here.
- Many well known scientists started their careers here. To name a few -
 Dr. John Mitchell, Dr. Harry Borthwick, Dr. Marion Parker, Dr. Mark Cathey, Dr. Albert Piringer, Dr. Peter Heinze, Dr. Robert Jack Downs, Dr. Harold Siegelman, Dr. Sterling Hendricks, Dr. Paul Marth, Dr. Theodore Diener, Dr. Russell Steere, Dr. George Stephens, Dr. J. Caldwell, Mr. Charles Washington Culpeper Dr. E. J. Kraus, Dr. Roman Kulwich, Dr. Arthur Mercuri, Dr. Anthony Kotula, Dr. John Yeatman, Dr. Rodger Dabbah, Dr. William Moats, and later in the Seed Quality Laboratory, Dr. Eben Toole, Mrs. Vivian Toole, Dr. Lowell Woodstock, Dr. Martin Kulick, Dr. Aref Abdul-Baki, Dr. James Anderson and Dr. Ram Chandra.

NOTE: For details contact Michael Combs,
 ARS National Visitor Center (301) 344-3992

Plant Molecular Biology Laboratory

United States
Department of
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Agricultural
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April 21, 1989

A New Focal Point

Years of careful research and field testing are needed for any advance in agricultural technology, but modern biotechnology promises to be a powerful catalyst.

Will biotechnology revolutionize agriculture for the better? Most experts say that "when" is a more appropriate question. When will today's fertilizers, pesticides, crops and livestock be improved through advances in biotechnology?

For crop biotechnology, the Plant Molecular Biology Laboratory, PMBL, at the Beltsville Agricultural Research Center in Maryland, is designed to help break down difficult technical barriers.

The PMBL is part of the U.S. Department of Agriculture's Agricultural Research Service (ARS). The laboratory cooperates with over 100 plant scientists in about 25 other laboratories at Beltsville, and with many other federal, state and industry scientists nationwide.

Its goals are to isolate genes that control plant metabolism, to develop reliable tools for transferring the genes and to find ways to regrow resulting transgenic plants. Modern analytical instruments have helped scientists gain a broad new understanding about the molecular chemistry, physics and genetics of agricultural crops. However, there are inadequate tools and limited information available to plant genetic engineers to exploit the new knowledge. One challenge is to get a handle on highly regulated, key enzymes that compose only one-millionth to one-thousandth of a cell's contents.

Biotechnology has produced its first genetically engineered, or transgenic,

plants. They are simple products, involving single gene changes--resistance to a plant disease, for example, or to a herbicide.

However, it is now feasible to work toward bioengineering multiple gene traits into crops--the ability to grow in poor soils and climates, provide their own nitrogen, to be more nutritious and become more efficient in photosynthesis. These traits present a far greater challenge to science.

Finding and Using Genes for Better Nutrients

(photo 89BW0501-45 on attachment)

Seed crops, such as beans and cereals, provide about 70 percent of the protein in the American diet. Proteins are made up of 20 different, simpler molecules known as amino acids, strung together in chains. Some amino acids are essential to the human diet but are naturally low in some of our most important seed crops.

PMBL scientists are working toward engineering specific genes that control amounts of essential amino acids in plant proteins. They must determine, at the biochemical and molecular levels, the signals that control synthesis and deposition of proteins in seeds.

In general, genes for seed proteins drive enzymes that manufacture amino acids. Modern instruments help scientists track the activity of the enzymes in order to isolate genes for the essential amino acids aspartate, lysine, threonine and methionine. The goal is to transfer a gene for high levels of one amino acid, lysine in beans, for example, into a crop such as corn, which is low in that nutrient.

NOTE: For details contact Stephen Berberich, ARS National Visitor Center (301) 344-2720.

Selecting Nutrient Quality in the Test Tube (photo 89BW0504-5A)

Scientists of the PMBL have pioneered a specific technique to improve protein quality in seeds. The technique, called inhibitor selection, originally developed for mutation studies of bacteria, has been applied to crops by the use of tissue culture.

Inhibitor selection allows scientists to sift through millions of plant cells to find one or a few that can be regrown into an amino acid-enhanced crop.

Rice was the pilot project. Small clumps of rice cells in dishes were flooded with a lethal dose of lysine and another amino acid. A very small number of cells that survived did not inhibit their own lysine production as usual. In most rice cells, inhibition of further lysine production occurs after the amino acid reaches a certain level.

So far, the technique has led to test-tube rice plants with higher protein content and a much needed improvement in levels of lysine. The experimental rice breeds true for up to 20 percent higher lysine. They are mutations of a commercial rice variety. The technique, applicable to other crops, can help breeders sidestep the labor and expense of years of random field work that may or may not turn up a high-lysine plant.

Finding How the Ripening Hormone Works

Ethylene is the ripening hormone in plants. Knowing more about how it is produced and how it operates at the molecular level could enable scientists to control aging of plants and regulate the timing of ripening.

Bananas are picked green and artificially ripened with ethylene before going to market. The same is possible with other fruits and vegetables. Ethylene controls the softening of fruit, presumably by increasing the enzymes that digest the wall of plant cells. PMBL scientists, with University of Maryland scientists, have demonstrated that genes requiring oxygen need to be active before ethylene will soften fruits.

In other studies, PMBL scientists have found three separate forms of ACC-synthase, a key enzyme in production of ethylene. They now hope to isolate the genes for ethylene production, study their traits and test ways to turn them on and off.

The idea is to silence the genes by genetic engineering in order to limit natural production of ethylene in fruits and vegetables without affecting the quality of the crop. After harvest, produce could be artificially ripened with ethylene, as with bananas, just before marketing.

Protein and Oil Storage in Seeds (photo 89BW0499-21)

Each year in this country, farmers produce 40 pounds of oil per person from soybean, peanut, sunflower, cotton and other crops. Plant seeds are a storehouse of protein and oil.

Genetic engineering and related biotechnologies open many possibilities to improve the nutritional composition of seeds, especially of protein and oil. One project at the PMBL is devoted to finding out how soybean seeds accumulate these substances.

The starting point is to study protein targeting, a process by which an individual protein component of the seed finds its proper destination within a cell. Understanding targeting will help scientists put genetic signals for improvements into agronomically important genes and to direct the gene's protein or oil product to a site in the cell where it is beneficial.

One of the techniques used is electron microscope immunocytochemistry. It helps scientist to find proteins in a cell. The ultra-sensitivity of the detection technique helps scientists to see molecules that are one-hundredth to one-millionth of a cell's contents. The technique uses gold-labeled antibodies to tag proteins on thin sections of tissue which are then observed in the electron microscope.

The "Light Meter" Protein in Green Plants (photo 89BW0498-42A)

Very quietly and mysteriously, in chloroplast factories in green leaves and stems, photosynthesis sustains life on this planet. Photosynthesis converts carbon dioxide from the atmosphere into other carbon-containing compounds that plants use to fuel growth.

No laboratory tools yet exist to alter genes found in higher plant chloroplasts, but researchers are engineering the genes that encode subunit proteins.

At the PMBL, scientists have charted the 12-hour life cycle of a type of plant protein that channels light energy into chemical energy needed for growth and development. Billions of these proteins, called 32kDa, are born and die in a leaf each day. The minute details of the protein's routine have been revealed to give scientists a gateway toward controlling the protein.

It seems to act as a light meter informing the plant when to adjust biochemically to changing light conditions. Identifying chemical signals that control the protein will permit scientists to steer such signals toward producing more growth in crops and increase food production.

The 32kDa protein was previously found to be a chemical weak point that makes plants yield to many herbicides. Charting its life cycle will also lead to crops that better resist herbicides.

And PMBL experiments have implicated the protein as a vulnerable point for ultraviolet light damage in plants. Scientists will try to use the 32kDa protein as an assay for UV light penetration into plant tissue. An assay is needed for estimating the crop damage from predicted increases in UV light penetration of the Earth's protective ozone layer.

Soybean Mapping and Breeding

Before engineering of plants is possible, a biochemical map of the genome, or gene endowment, is needed for each major crop

species. Gene mapping gives scientists a picture of where to look for genes of agronomically important traits. The arrangements of basic units--DNA codes--in genes are needed, as well as locations of bits of DNA, the promoters and regulators, that regulate gene expression,

The idea is to shorten the time it takes to develop a new cultivated variety, a cultivar. It is important to know if the genes for certain traits are found on the same or different chromosomes.

For example, a soybean breeder may be aiming for a variety with two new traits, resistance to nematodes and nonblack seeds. The black color can turn soy oil-based margarine gray. If genes for non-black (beige seeds) and nematode resistance are linked on the same chromosome, the time and expense of growing 100,000 progeny of a cross yields only 42 plants with both genes. If they are not linked, only 1,000 progeny are needed to get 62 plants with both traits--enough for further breeding. The figures illustrate that mapping the genes on chromosomes before making crosses improves planning. Mapping permits breeders to avoid annoying gene linkages.

Gene maps will also help the U.S. Patent Office to identify genetically engineered plants.

Developmental Gene Studies (photo 89BW0561)

Genes that affect specific stages of a plant are called developmental genes. Identifying and engineering them can help scientists exploit photosynthesis and improve yield, nutritional quality, and disease resistance.

So far, PMBL scientists are zeroing in on two types of developmental genes--those that control how seeds mature and others that control abscission, the shedding of leaves, flowers or fruit.

When a plant "decides" it is time to shed leaves because of environmental stress or impending maturity, it dissolves cell walls in a narrow, 3-cell-wide abscission zone at the base of the leaf petiole. A similar process takes place before flowers or fruit fall off.

The challenge for biotechnology is to manipulate genes that differentially regulate the shedding process. Agriculture would dramatically improve certain crops if scientists could gain more genetic control over the timing of leave and fruit shedding.

Soybeans, for example, lose 60 to 80 percent of their flowers or young fruit before the plant matures. Suppressing abscission would greatly improve yields. One approach is to engineer a gene for increasing the growth hormone, auxin, which tends to add new leaves and delay abscission of older ones. The scientists are working on fusing a portion of the gene for cellulase, an abscission enzyme, and an auxin synthesis gene. The fused gene will then be transferred into soybean. The effect may be to genetically inhibit abscission of flowers and young fruit.

Engineering Hormone Balances in Tissue Cultures

(photos 89BW0505-43 and 89W0506-19A)

The tides of genetic engineering depend ultimately on undercurrents of tissue culture technology. In other words, an engineered change in the genetics of a cell or tissue is useless if scientists cannot regenerate those cells into whole, reproducing plants.

Growing bits of tissue in the proper mix of nutrients and hormones in a test tube enables cell division and growth to take place. In some species, scientists have learned how to adjust hormone balances in the growth medium to induce tissue to specialize into roots and/or shoots. However, it is not yet possible to regenerate whole plants of most of the important agricultural crops.

In the PMBL, scientists have shown that it is possible to use genetic engineering to manipulate the synthesis of hormones in tissue. New balances of the growth hormone, cytokinin, and the root hormone, auxin, can be stimulated. The experiments, on cucumber and tobacco tissue, are a major step toward regenerating major crop species.

The scientists selected varieties of cucumber and tobacco for their tests that respond poorly or not at all to cytokinin applied to tissue culture. They fused the shoot hormone gene onto a strong hormone-promoter gene from cauliflower. They inserted a reconstructed gene into bacteria and the bacteria, in turn, injected it into tissue. The new gene stimulated vigorous shoots in tobacco tissue and some shoots in cucumber that received the reconstructed gene.

Biotech Changes in Peach, a Woody Precedent

(photos 0887x929-3 and 89BW0507-22A)

A project will be continued in the PMBL in which ARS scientists were recently first to engineer disease resistance into a woody plant, in this case peach, via a tissue culture technique. The significance is clear. Developing a new cultivar of a woody plant--for an orchard crop or landscape trees or shrub--takes decades of breeding. Genetic engineering and tissue culture technologies will save time and money.

A PMBL scientist screened millions of peach cells for resistance to a toxin produced by a disease-causing bacterium. A few cells that survived the treatment were regenerated into whole plants that showed a high level of resistance. These plants are being tested in the field for the trait.

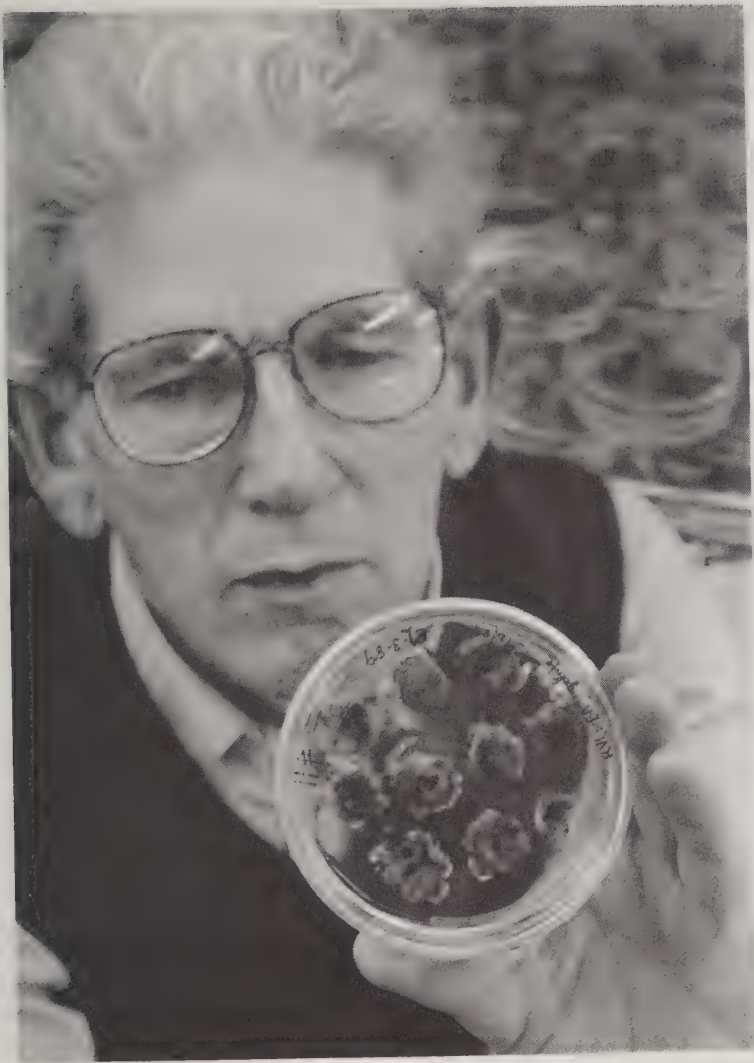
The scientist also developed a tissue culture propagation system to mass-produce peach trees on their own roots--as opposed to the common practice of root grafting. The tissue-cultured trees produced 10 times more peaches than conventionally propagated trees in the first years in the orchard. They also produced a marketable crop one year earlier than grafted peach trees.

Recently PMBL scientists have also been able to use genetic engineering to change the hormonal balance of peach tissues in culture--as they did with cucumber and tobacco. This development could remove a major barrier to genetic engineering in peaches, as well as in other woody crops.

Captions for photo layout. Photos correspond to numbers on the sections.



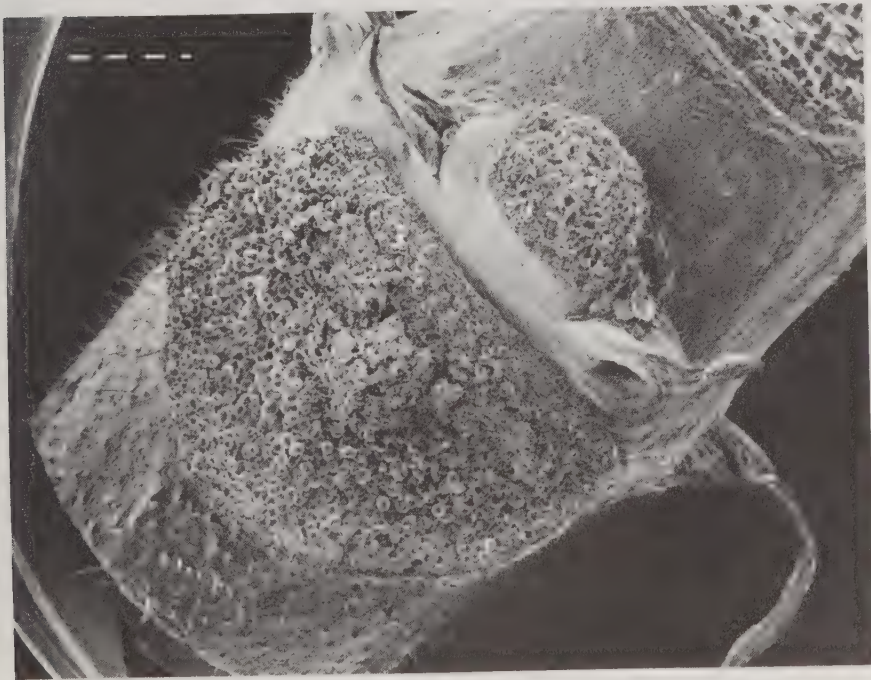
Selecting for Nutrition in the Test Tube
Gideon W. Schaeffer has pioneered a tissue-culture technique that led to higher quality protein in rice. (89BW0504-5A)



Engineering Hormone Balances in Tissue Cultures

Lowell Owens with tissue culture of soybean plants. (89BW0505-43)

Ann C. Smigocki with engineered tobacco plants. (89W0506-19A)



Developmental Gene Studies

Soybean stem abscission zone exposed after a leaf falls off. (89BW0561)



Biotech Changes in Peach, a Woody Precedent

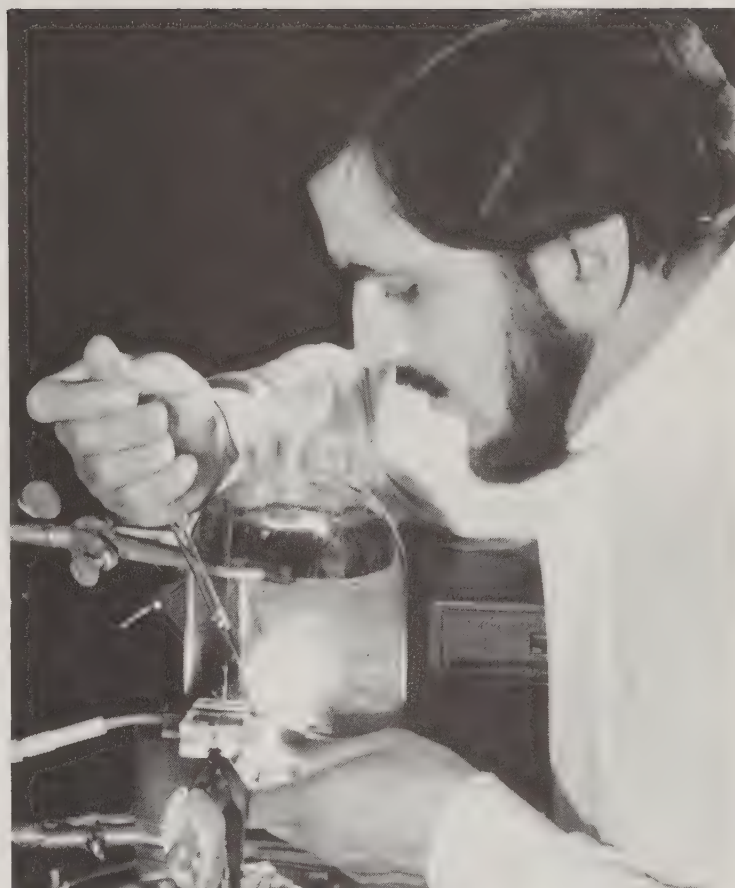
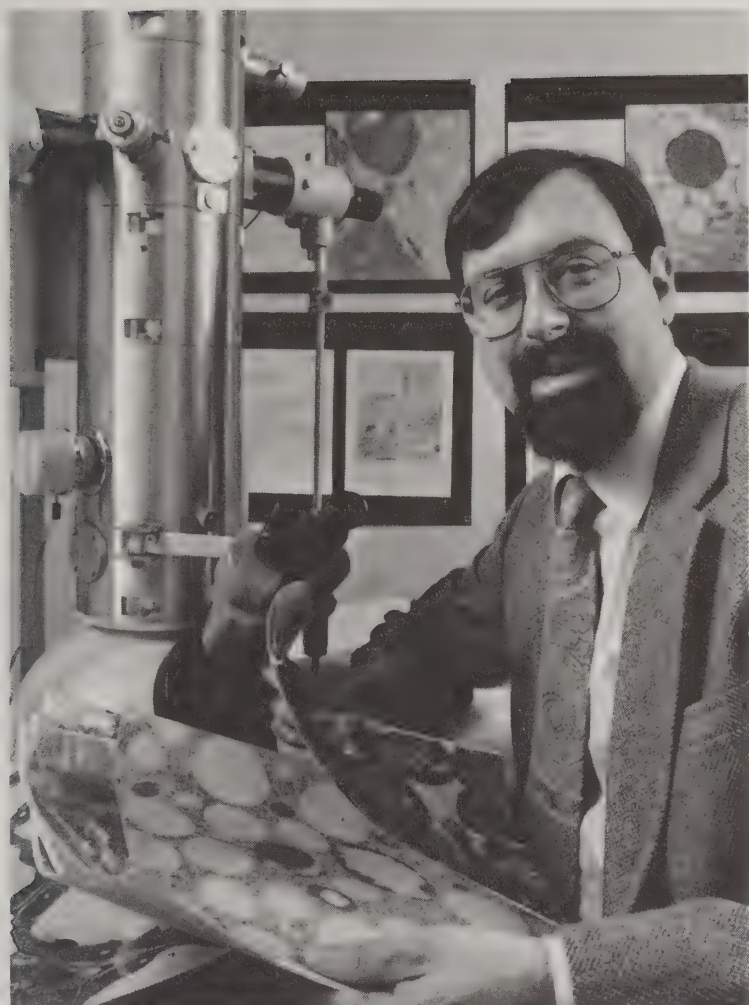
Freddi A. Hammerschlag and peaches from tissue-cultured trees.
(0887x929-3)

A few cells of peach tissue survived screening and were grown into disease resistant plants. (89BW0507-22A)



Finding and Using Genes for Better Nutrients

Benjamin F. Matthews and a high performance liquid chromatograph. (89BW0501-45)



Protein and Oil Storage in Seeds

Eliot M. Herman uses immunocytochemistry and an electron microscope to identify protein components in seeds. (89BW0499-21)

The "Light Meter" Protein in Green Plants

Autar K. Mattoo adds chloroplasts to an oxygen electrode in photosynthesis study. (89BW0498-42A)

NOTE: Black and White 8x10 glossy prints and color slides are available from Anita Daniels, USDA-ARS Photography Room 306, Building 005, Information Staff, Beltsville, Md. 20705
Telephone: (301) 344-3357.

Plant Molecular Biology Laboratory

United States
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BACKGROUND BIOGRAPHIES

EDWARD B. KNIPLING, Ph.D., is the Director of the Beltsville Area laboratories of ARS. He began his career with ARS in 1968 as a research plant physiologist in Gainesville, Florida. He has also served as Area Director for ARS in Stoneville, Mississippi, Area Director for the California-Hawaii-Nevada Area, in Fresno, California, and Associate Deputy Administrator for Plant and Natural Resource Sciences, National Program Staff.

R. DEAN PLOWMAN, Ph.D., was appointed as the Administrator, Agricultural Research Service on April 15, 1988. From 1956-1984, Dr. Plowman has served ARS in positions of increasing responsibility. He headed a group of scientists in planning, organizing, and conducting long-term studies on basic genetics, the application of advanced genetic concepts and principles to the improvement of dairy cattle, and studies of management factors which affect production characteristics. He was the Director of the ARS Animal Genetics Improvement Laboratory, which was instrumental in the development of the current USDA sire summary procedures and in getting them adopted by all segments of the dairy industry.

ORVILLE G. BENTLEY, Ph.D., serves as the Nation's first Assistant Secretary for Science and Education. He was sworn in October 19, 1982. He is responsible for USDA research, education and extension programs in the food and agricultural sciences. He has general supervision of the Agricultural Research Service, the Cooperative State Research Service, the Extension Service, and the National Agricultural Library. In 1984 and 1988 he led the U.S. delegation in the Indo-American Subcommission on Agriculture meeting in New Delhi.

CHARLES J. ARNTZEN, Ph.D., was appointed Deputy Chancellor and Dean of Agriculture of Texas A&M University System in March, 1988. In December, 1970, Dr. Arntzen was appointed Assistant Professor of Plant Physiology at the University of Illinois-Urbana. He rose to the rank of Professor in 1978. He served as a research scientist with the U.S. Department of Agriculture from 1976-1980. In June, 1980, he was appointed Director of the DOE Plant Research Laboratory at Michigan State University. He accepted the position of Director of Plant Science and Microbiology at the Du Pont Experimental Station at Wilmington, Delaware in 1984 and was promoted to Director of Biotechnology Research in January, 1987.

SUMMARY OF SCIENTISTS AND THEIR RESEARCH

Dr. Autar K. Mattoo
Research Leader, and
Supervisory Plant Physiologist
200, Bldg. 066, BARC-W
Beltsville, MD 20705
301/344-3622

Regulation of gene and protein processes that control postharvest senescence and wounding responses of higher plants, with particular emphasis on the hormonal involvement. Regulation of biosynthesis, maturation, assembly and function of the photosystem II reaction center polypeptides. Light control of

Dr. Thomas E. Devine
Research Geneticist
Room 201, Bldg. 006, BARC-W
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301/344-4375

Dr. Freddi A. Hammerschlag
Plant Physiologist
Room 14, Bldg. 006, BARC-W
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Dr. Eliot M. Herman
Plant Physiologist
Room 202A, Bldg. 006, BARC-W
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Dr. Benjamin F. Matthews
Plant Biochemist
Room 109, Bldg. 006, BARC-W
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301/344-2730

Dr. Lowell D. Owens
Plant Physiologist
Room 1-A, Bldg. 006, BARC-W
Beltsville, MD 20705
301/344-4072

turnover of plant proteins with particular emphasis on primary determinants and signals involved. Interaction of UV and visible light in conjunction with free radicals in mediating degradation of chloroplast proteins.

Soybean genetics. Genetic linkage mapping of the soybean genome. Integration of RFLP, isozyme and morphological genetic maps. Location of disease resistance genes on chromosomes.

Cell and tissue culture of woody plants. Selection and screening of somaclonal variants for disease resistance. Rapid propagation of woody plants via tissue culture. Identification of genetic, biochemical and physical requirements for growth, differentiation and vegetative propagation of woody plants. Genetic stability of cells in culture. Gene transfer into peach plants and characterization of transgenic plants.

Cell and molecular biology of seed proteins. Expression of soybean oil body proteins. Expression and targeting of seed proteins in transgenic tobacco. Immunocytochemistry of protein expression.

Plant biochemistry and molecular genetics. Examination of the biosynthesis of amino acids at the DNA, mRNA and protein levels. Development of gene transfer methods for bypassing traditional sexual breeding barriers. Restriction fragment length polymorphism (RFLP) mapping of the soybean genome.

Cell and tissue culture biology. Development of techniques for the transfer and expression of foreign genes in crop plants, with emphasis on sugarbeet and soybean. Use of phytohormone specifying genes to induce morphogenesis or alter plant development. Characterization of phytohormone levels in transgenic cell lines of plants. Design and introduction into crops of genes encoding antibacterial polypeptides.

Dr. Gideon W. Schaeffer
Plant Physiologist/Biochemist
Room 100A, Bldg. 006, BARC-W
Beltsville, MD 20705
301/344-4342

Genetic research in cell, tissue and anther culture of cereals (rice and wheat), the biochemical selection of cell types for male sterility, nutritional quality (improved lysine and protein), and disease resistance and characterization of mutants. Gene identification and isolations. Restriction fragment analysis and recombination of mutant and wild type DNA and regulation of gene expression during seed and seedling development.

Dr. Ann C. Smigocki
Research Geneticist (Plants)
Room 2, Bldg. 006, BARC-W
Beltsville, MD 20705
301/344-1848

Plant molecular genetics. Phyto-hormone gene modification and transfer mediated by Ti plasmid or electroporation. Relation of phyto-hormone gene expression to morphogenesis. Molecular biology of sucrose transport in sugarbeets.

Dr. Mark L. Tucker
Plant Molecular Physiologist
Room 208, Bldg. 006, BARC-W
Beltsville, MD 20705
301/344-1091

Tissue-specific and hormonal regulation of plant gene expression. Cellulase gene expression is used as a model gene. Identification of cis- and trans-acting factors which influence transcription of the genes in this small family of genes. Potential for application to the regulation of fruit, leaf, and flower abscission, male sterility, and fruit softening.

Scientific Research News

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Agricultural Research Center
Beltsville, MD 20705

A generation ago, no one dreamed of the unprecedented opportunities that modern biotechnology is now creating in the study of basic life processes. In agriculture, genetic engineering and related biotechnologies are powerful catalysts to advancement.

The Agricultural Research Service, principal research agency of the U.S. Department of Agriculture, is a world leader in using biotechnology to help solve complex problems in food and agricultural industries. Currently the agency devotes \$54 million for research in biotechnology.

Here is a selection of recent ARS research findings:

CROP RESEARCH

Soybeans and other legumes will provide a more complete source of protein when a corn gene for sulfur storage can be bioengineered into the crops. Legumes are usually very low in sulfur-containing essential amino acids. As a start, scientists have inserted corn's sulfur-storage gene into tobacco cells and have grown back plants with high levels of

Note: One or more scientists familiar with each research project are listed for further information. If the scientists are unavailable, others at the same telephone number may also be familiar with the work.

Items marked with the word PATENT are being patented by ARS. For more information contact Ann Whitehead, National Patent Program, Bldg. 005, Rm. 401, Beltsville Agricultural Research Center, Beltsville, MD 20705, (301) 344-2786.

sulfur and sulfur-containing substances. Legume varieties with high-sulfur amino acid can be developed only after scientists can regenerate seed-bearing soybeans and other plants from bioengineered cells. Meanwhile, the achievement with tobacco--as a model--helped scientists polish gene-inserting techniques.

Plant Molecular Biology Lab,
Beltsville, MD
Eliot M. Herman, (301) 344-3258

A new diagnostic super-kit will quickly detect some of the world's most damaging viruses to plants and seeds in one test. Within a few months, Agdia, Inc., of Indiana will develop a prototype kit through a technology transfer agreement with ARS. The kit is based on ARS-developed monoclonal antibodies that react to a site on a protein molecule common to most, if not all, potyviruses. Named after potato virus Y, potyviruses affect many important crops including corn, soybeans, wheat, lettuce and other vegetables, and ornamentals such as tulips and Easter lilies. Seed-testing firms, nurseries, government agencies that quarantine plants, and farmers are among the kit's potential customers. So far, the kit can detect at least 30 potyviruses. Prior to this kit, there existed only tests for a single potyvirus, or a few closely related strains, and those have to be run one at a time.

Florist and Nursery Crops Lab,
Beltsville, MD
Ramon L. Jordan, (301) 344-1646

Now seedless grapes can have seedless parents. Grape breeders until now used a seeded female to produce seedless grapes, with a success rate of only about 10%. A new lab method accelerates the development of hybrid grape seedlings possessing the seedless trait. Even so-called seedless grapes have seeds in early stages of development, but they

abort and disappear before maturity. By using the immature seed before abortion and growing it on tissue culture, a plant can be grown for use in hybrid breeding. Preliminary tests show a 35% to 70% successful seedless rate. This means about a 50% increase in plants producing seedless grapes.

Horticultural Crops Lab,
Fresno, CA
Richard L. Emershad, (209) 487-5334

The genetic address of higher yielding corn is being mapped by tagging corn chromosomes with previously identified unique gene sequences. The tags are used to identify chromosomes that control yield and other traits, such as disease resistance and sturdiness. Researchers have already tagged several sequences on the chromosome that directly affect yield, allowing them to manipulate yield in either direction by selecting corn lines for the presence or absence of those gene sequences.

Plant Science Research Lab,
Raleigh, NC
Charles W. Stuber, (919) 737-2289

Certain genes in wheat dictate the quality of flour used for breadmaking. ARS researchers and colleagues in England have worked out the intricate structure (nucleotide sequence) of two genes thought to be responsible for high-quality flour. These genes "tell" the wheat plant to manufacture special glutenin proteins usually found in superior flour. Knowing the exact sequence of the genes will help scientists improve the genetic makeup and thus the breadmaking quality of wheat varieties.

Plant Development-Productivity, Western Regional Research Center,
Albany, CA
Frank C. Greene, (415) 559-5614

Despite the sexual incompatibility between many wild and cultivated potatoes, scientists can now tap genetic reservoirs in both the nucleus and the surrounding cytoplasm in cells of wild potato plants. They can identify economically desirable genes in wild spuds, moving the genes into potatoes by using somatic hybridization. That means fusing together protoplasts--cells stripped of walls--of wild and cultivated varieties

and growing back whole plants. Some surviving somatic hybrids, scientists recently found, had genes in their chloroplasts (bodies in the cytoplasm) that were identical to genes in chloroplasts of the wild parent. The hybrids can pass on these chloroplast genes sexually; the eventual result could be cultivated potato varieties with such desirable characteristics as more efficient photosynthesis and better disease resistance. Plant Disease Resistance Research,
Madison, WI
John P. Helgeson, (608) 262-0649

Virus Diseases of Small Fruits is the title of the new Agricultural Handbook Number 631. Crops covered are strawberries, blueberries and cranberries, currants and gooseberries, and blackberries and raspberries. This 277-page handbook, compiled by international authorities, includes discussions of the history, geographic distribution, importance, symptoms, transmission, cause, detection, and control of virus and viruslike diseases attacking these crops.

Horticultural Crop Research Lab,
Corvallis, OR
R.H. Converse, (503) 757-4544

Sweetpotatoes release a group of chemicals that can suppress weeds, scientists found. They took a sweetpotato that ARS originally released to resist insects, diseases and nematodes and tested extracts from its skin against weeds. In tests, one group of chemicals--called phenolics--was especially active at suppressing germination of eight weeds: velvetleaf, proso millet, morningglory, goosegrass, black nightshade, pigweed, cassia and eclipta. Scientists foresee three benefits from the research. Breeders could develop new weed-resistant varieties in much less time by selecting plants with high levels of these chemicals instead of having to grow and test multiple strains of plants. The crop could also be genetically engineered to produce phenolics continuously. And chemical companies could develop synthetic phenolics for new pesticides. The researchers are also testing the effects of phenolics on bacteria and nematodes. U.S. Vegetable Lab,
Charleston, SC
Joseph Peterson, (803) 556-0840

Spinach leaves and mouse-ear cress are providing scientists with clues that bring them closer to genetically engineering many crops for improved photosynthesis. ARS researchers have isolated and cloned a gene responsible for the enzyme, rubisco activase. This enzyme helps plants adjust to changes in light intensity during the first step in photosynthesis--converting atmospheric carbon dioxide to sugar. Now scientists can transfer modified versions of the cloned gene into chloroplasts (part of the plant cell that contains chlorophyll) to see which versions work best in different environments.

Photosynthesis Research,
Urbana, IL

William L. Ogren, (217) 244-3082

In this age of biotechnology, does tissue culture mean better? Scientists say yes. They compared nutrient concentrations in apple leaves regenerated from lab-cultured cell tissue with leaves of the same varieties grown from buds grafted onto seedlings and root stock. Results from the 3-year study showed that the leaves of tissue-cultured trees contained more calcium. These trees also took up nutrients more efficiently. Further study is needed to see if more leaf calcium means more fruit calcium. Advantages of tissue culture include lower production costs, tree uniformity for easier management and shorter time to planting.

Fruit Lab, Beltsville, MD

Ronald F. Korcak, (301) 344-4650.

Appalachian Fruit Research,
Kearneysville, WV

Stephen S. Miller, (304) 725-3451

New tissue culture techniques allow scientists to regenerate numerous plants from one seed of a stone fruit like the European plum, peach and sour cherry. Using thidiazuron--a cotton defoliant that can regulate growth--scientists can now regenerate as many as 15 to 20 plants from one seed's cotyledon. This is the part of the embryo that stores food. With the new method, rooted plants are ready for the greenhouse in just 90 to 100 days, and only two growth media are needed. Current culture methods using the embryo take up to twice the time and require four growth media. ARS

and Cornell University researchers, while working with stone fruits (Prunus), discovered that the new method also regenerates soybean plants more efficiently and rapidly than current methods. The cotyledon method can lead to new soybean varieties (including those genetically engineered) and improved Prunus rootstock.

Appalachian Fruit Research Station,
Kearneysville, WV

Ralph Scorza, (304) 725-3451

Keeping potato plant shoot tips in the dark, a new tissue culture method, may make them healthier and cheaper to grow. The new method, likely to be adopted by other potato breeders, researchers, and seed producers, could help lower costs to potato growers and provide better quality, more competitive varieties in the marketplace. Currently, cultures of disease-free clones (or mother plants) are grown in light and then cut into pieces and transferred to fresh nutrients several times a year. With the new method, clones are stored in a refrigerator at 50°F, where a culture medium high in sugars and plant hormones induces small disease-free cuttings of these clones to form tiny tubers. These micro-tubers can be stored up to 2 years and replanted with 95% success, saving the cost of transferring the plants to new culture media every 3 or 4 months. The technique has already reduced the cost of breeding potatoes in the lab where about 400 clones are maintained as microtuber-forming cultures.

Irrigated Agriculture Research and
Extension Center,
Prosser, WA

Charles R. Brown, (509) 786-3454

A group of special proteins that corn plants produce at times of drought or salty conditions could hold the key to eventually developing plants that can better withstand such adverse conditions. Studies in the lab have shown that when clusters of corn cells are subjected to too much salt or too little water, the cells will manufacture three proteins not found in other cells free of such stresses. Likewise, when corn seedlings were deprived of water, they reacted by synthesizing two other proteins that were not produced by their well-watered

counterparts. Those two proteins rapidly disappeared when the tiny plants were watered. A plant's genes instruct it when to produce these proteins. If these genes can be isolated, scientists hope to use biotechnology to genetically engineer more tolerant varieties of corn as well as transfer these tolerance genes into other plants.

Sugarcane Physiology,

Aiea, HI

Subbanaidu Ramagopal, (808) 487-5561

Sowing the genes of wild oats into commercial varieties could lead to bioengineered or conventionally bred oats that resist disease, insects and pesticides and have other good traits. That's because scientists have bred new oat lines with all the maternally inherited genes from wild oat cytoplasm--the cell region outside the nucleus. This is important because today's oat varieties lack adequate genetic diversity in the cytoplasm; in corn this problem spurred a 1971 epidemic of Southern corn leaf blight. Now the scientists are checking the new oat lines for desirable traits conferred by cytoplasmic genes. These lines produced as much grain as the high-yielding paternal ancestors from which they got most of their nuclear genes.

Plant Science Research,

St. Paul, MN

Howard W. Rines, (612) 625-5220

A newly discovered plant enzyme may, through genetic engineering, lead to soybeans and other crops that will be more efficient at photosynthesis--converting atmospheric carbon dioxide to sugars. ARS scientists discovered the enzyme, carboxyarabinitol-1-phosphatase in spinach and tobacco leaves. In these plants, the enzyme starts working at sunup. It cleaves a phosphate compound that leaves produce at night to block the activity of rubisco, an essential enzyme in the first step of photosynthesis. Without the newly discovered enzyme, rubisco wouldn't switch on after sunrise. One idea being explored is whether the new enzyme could be altered to start work at lower light intensities--earlier in the morning or under heavy cloud cover.

Tobacco and Forage Research,

Lexington, KY

Michael E. Salvucci, (606) 257-2683

Walnut trees of the future may be able to rely on borrowed genes to ward off damaging insects and diseases, now that scientists have transferred a foreign gene into walnut embryos. Some experimental embryos--the beginnings of the familiar nutmeat--took up the gene and have produced plants that also contain the active gene. Since this marker gene--not useful in walnut trees--proved that a gene can be taken up and work, subsequent embryo experiments will use other useful genes to confer traits such as resistance to codling moth. Such transfers of genes into embryos may be the best technique yet for moving valuable traits into walnuts, pecans, almonds, grapes, cherries and peaches.

Crops Pathology and Genetics Research,
Davis, CA

Gale H. McGranahan, (916) 752-0113

A salt bath or bed of gelatin may be the newest and best way to gently release a pollen cell's contents--intact. Using the bath or gelatin may avoid the damage that scientists suspect results when other tactics are used to release cell contents (protoplast) from leaf, stem and root cells. Researchers expect that pollen protoplasts freed by the new methods can be nurtured into healthy plantlets. If so, this could simplify plant breeders' search for superior plants with desirable, gene-controlled traits, because the pollen plantlets would contain only the genetic material of one parent--the male. Plantlets produced from leaf, stem or root protoplast, in contrast, contain genes of both parents. Other possible applications of the research: Genetic engineers might be able to infuse bath-extracted protoplasts with useful new genes. Or, they might be able to use them in protoplast fusion, a technique that makes it possible to produce new hybrids by fusing protoplasts of plant species that don't breed with each other in nature. The saline bath safely pops protoplast out from the protective walls of green bean pollen cells. The gelatin technique shatters the cell wall to release protoplasts of green peppers, tomatoes, lima beans, cucumbers,

zucchini, soybeans and black-eyed peas.
(PATENT)

Plant Development-Quality Research,
Western Regional Research Center,
Albany, CA
Merle L. Weaver, (415) 559-5760

DROUGHT-RELATED RESEARCH

The carbon in a wheat plant may be a tipoff on how well it can withstand drought. Scientists are now examining the ratio of two different natural forms of carbon, C₁₂ and C₁₃, in winter wheat. They are also using infrared thermal "guns," gas-measuring equipment and portable chambers to measure plant response to drought. They hope to identify wheats with superior resistance that could be used to improve plant varieties.

Great Plains Systems Research,
Fort Collins, CO
Jack A. Morgan, (303) 491-8224

Scientists have found a single recessive gene, tr, that substantially increases drought tolerance in pearl millet, a crop grown as a forage in the United States and as a grain in many arid Third World countries. The gene's physical expression--leaves with a thick, shiny wax cuticle or "skin" and without tiny surface hairs--helps the plant conserve moisture. Under drought conditions, pearl millet with these traits had forage yields as much as 25% higher than equivalent varieties without the traits. With adequate water, yields were similar. Drought tolerance conferred by the tr gene could be a major plus in areas where pearl millet is a grain crop. Yield increases are offset when the crop is grown for forage because the waxy cuticle makes leaves less digestible. Future improvements in genetic engineering may allow the tr gene to be introduced into other grain crops, improving their drought tolerance.

Coastal Plain Experiment Station,
Tifton GA,
Glenn W. Burton, (912) 386-3353.

SCIENTIFIC INFORMATION SYSTEMS

Cheese producers could benefit from some recent discoveries about the molecular structure of caseins, the major group of proteins found in milk. Ever since caseins were first studied nearly 60 years ago, scientists have been unsure about their collective molecular structure and interaction with water. The result has been a continual and costly measure of unpredictability in the production of cheese and certain dry-milk products. Now, through a unique combination of lab techniques called small-angle X-ray scattering and NMR (nuclear magnetic resonance), scientists have finally mapped that structure and determined how it traps water in a way that enables caseins to be clotted through enzyme activity. Such clotting is critical to cheesemaking, and understanding the molecular dynamics behind it will help food technologists develop more effective and reliable processing methods.

Macromolecular and Cell Structure
Research Lab,
Philadelphia, PA
Thomas F. Kumosinski, (215) 233-6475

ANIMAL PRODUCTION & PROTECTION

To help pig breeders produce leaner porkers, scientists can now harmlessly predict a pig's genetic tendency toward obesity. Cultures of fat cells from rats developed faster when "fed" serum from genetically obese fetuses and young pigs than they did when given serum from lean pigs. Now the scientists plan to identify serum factors such as hormones, proteins or other substances, to explain the test results.

Animal Physiology Research Lab,
Athens, GA
Gary J. Hausman, (404) 546-3224

When can scientists know if a gene they insert in an animal embryo takes hold? Up to now, they've had to wait until the animal is born to get the answer from a standard test. A new gene-copying system, successful in mice but designed for future use in cattle, will save them a long wait--a cow's approximately 230

day gestation period. Five to seven days after injecting a new gene, they will split the embryo into identical twins. One twin embryo will be used for the gene-copying technique, in which as few as 25 of its cells are mixed with an enzyme, polymerase. If the injected gene is present, polymerase makes a million or more copies--enough for the standard test to determine the gene's presence. If the result is positive, scientists will implant the other twin in a surrogate animal mother. The new copying system could save money and time while assuring scientists that their gene engineering tests are on track.

Reproduction Lab,
Beltsville, MD
Donna King, (301) 344-1500

Cattle, like humans, inherit the ability to resist disease from their parents. Researchers are developing blood tests to identify groups of cattle genes associated with disease resistance that can be used as genetic markers. These gene markers may lead to improved disease resistance in future U.S. cattle breeds, thereby reducing annual veterinary bills and animal losses in the millions of dollars. If researchers can identify the specific genes for disease resistance that are associated with the markers, it may be possible to insert these genes into cattle embryos. The markers will also aid breeders in selecting disease-resistant cattle.

U.S. Meat Animal Research Center,
Clay Center, NE
Roger T. Stone, (402) 762-4166

Transgenic chickens that can resist avian leukosis virus have been bred by ARS scientists--paving the way to potential savings for U.S. egg producers \$50 to \$100 million a year. Transgenic means genes are transferred from one species to another--in this case from a weak strain of this virus to chickens. The virus cannot infect humans, but in chickens it can reduce egg production and quality. In hundreds of attempts to get virus genes to "take," scientists squirted virus through the egg shell near the day-old embryo and then hatched the egg. Transgenic chickens bred from a second-generation descendant of one of these embryos resisted lab and field

strains of the avian leukosis virus in tests lasting 40 weeks. Ordinarily, the virus commands chicken cells to make more virus particles. But cells in the resistant birds make only the virus "envelope," or empty virus shell. With more research, virus genes may become "locomotives" for transporting "freight trains" of other beneficial genes so that chickens could resist other diseases, grow faster on less feed or lay larger, higher quality eggs.

Regional Poultry Research Lab,
East Lansing, MI
Lyman B. Crittenden, (517) 337-6828

The first vaccine against parasitic cattle grubs should be ready for testing in a few months. Cattle grubs--heel fly larvae--are worldwide pests. Grubs damage hide and meat, and adult flies annoy cattle, interfering with feeding and reproduction. Total annual losses in the United States are estimated in the millions of dollars. Now under a technology transfer agreement, a California biotech firm, Codon, will genetically engineer Escherichia coli bacteria to mass-produce a natural protein isolated from grubs by ARS scientists. The protein triggers an immune response in cattle that is fatal to grubs. A vaccine made from this protein will give calves protection that their parents develop only after they have been infested for a year or more. Grubs live 6 to 8 months inside cattle before cutting breathing holes through the hide and eventually emerging as buzzing flies.

U.S. Livestock Insects Lab,
Kerrville, TX
John H. Pruett, Jr., (512) 257-3566

All neutrophils are not created equal. Researchers have discovered these white blood cells that engulf and kill foreign intruders come in four types--at least in cows. The finding, the first of its kind in any animal, could lead to the breeding of more disease-resistant cattle. It may also explain long-noted differences in the ability of these white blood cells to move to an infection site and kill invading bacteria. To separate the four types of neutrophils, scientists tested cow blood samples with custom-designed proteins called monoclonal antibodies.

These antibodies are like guided missiles and "home in" on only the targets they are programmed for. The antibody test could be used to identify cows with active neutrophils; those cows in turn become the parents of more disease-resistant breeds.

Milk Secretion and Mastitis Lab,
Beltsville, MD

Max J. Paape, (301) 344-2302

Cattle and ticks infected with the blood disease anaplasmosis can now be diagnosed by detecting the parasite's DNA (genetic material). The test, which could ultimately save U.S. cattlemen about \$100 million annually, is very specific and has greater sensitivity than other techniques currently in use. Carried by ticks, anaplasmosis infects the red blood cells of cattle worldwide, resulting in anemia. Controlling the disease has been difficult, since no techniques exist to quickly or reliably identify chronically infected cattle or infected ticks. Since DNA of a given species is unique, parasite DNA that researchers label with a radioactive tracer can be used to probe or test samples for the presence of the disease.

Animal Diseases Research,
Pullman, WA

Willard L. Goff, (509) 335-3179

Adipsin, a protein that controls the size of fat cells, has finally been detected in chickens. The discovery could ultimately lead to lower feed costs for broiler producers and leaner, meatier chicken for consumers. Modern broiler chickens have been bred to grow faster than their ancestors, but this growth has resulted at least a 100 percent increase in fat over the bird of 30 years ago. Basically, this increase in fat is attributable to an increase in fat cell size more than to an increase in number of fat cells. Having now detected adipsin in the chickens' fat cells, ARS scientists are working on genetic probes to determine which genes control its production and whether that production will respond to genetic engineering or drugs.

Poultry Research Lab,
Georgetown, DE

Teresa L. Blalock, (302) 856-0046

SOIL, WATER AND AIR

Too much aluminum in acid soil, in scientists now know, prevents enzymes corn root membranes from doing what they are supposed to do--letting nutrients into the plant. But when roots get normal amounts of oxygen (from the soil) and glucose (from photosynthesis), the aluminum is trapped in the walls of root cells. Adding calcium lime to the soil, a recommended practice, can reduce but not completely stop aluminum's harmful effect. Scientists found about these mechanisms using nuclear magnetic resonance spectroscopy (NMR), which can examine plant root activity in living tissue as it happens. This new information could be used to genetically engineer aluminum-resistant crops and improve management practices on acid soils.

Plant and Soil Biophysics Research,
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